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THE IMPACT OF RACE AND AFFECT ON INFANT VISUAL ATTENTION TO FACES

Introduction

Perceptual narrowing is a mechanism of development in infant facial processing. According to Xiao, Quinn, Lee, and Pascalis (2017), perceptual narrowing is a decline in infant discrimination of stimuli, whether they be familiar or unfamiliar. These stimuli can be visual, auditory, or multimodal, and these narrowing effects may last through the infant's lifetime. It is thought that perceptual narrowing is a result of experience, or lack thereof, with certain stimuli (Sugden & Marquis, 2017). While the process of development in infant perception is often thought of as a progressive developmental process, it is inherently regressive, as some perceptual abilities are lost or show decline. Lewkowicz and Ghazanfar (2009) detail this, stating that older infants may only distinguish between "socio-ecologically-relevant multisensory signals," rather than the variety of signals they were once able to discriminate. Lewkowicz and Ghazanfar (2009) state that this mechanism of development, though regressive, is crucial component of perceptual development. Similarly, it is thought that this narrowing in perception helps humans respond more efficiently to stimuli in their environment (Sugden & Marquis, 2017).

As an infant becomes accustomed to being surrounded by a certain race, species, or gender, their ability to distinguish between faces narrows to those types of faces they are regularly exposed to. Likewise, as infants become more familiar with certain native sounds, their ability to distinguish native voices increases and their ability to distinguish non-native voices decreases (Lewkowicz & Ghazanfar, 2009, Werker & Tees, 1984, Xiao et al., 2017). Furthermore, younger infants may be able to discriminate visually between native and non-native articulations of speech while older infants lose this ability before 8 months of age (Lewkowicz & Ghazanfar, 2009).

The Other Race Effect (ORE) is a well-established result of attentional development and perceptual narrowing in which the ability to distinguish other-race faces significantly decreases before the age of 9 months (Kelly et al., 2007, Liu et al., 2011). Contrary to Lewkowicz and Ghazanfar's (2009) description of perceptual narrowing as a regressive process, Liu and colleagues (2011) describe the process as infants gaining "expertise-like" scanning processes of their own race. While it is certain when the Other Race Effect Develops in infancy, there are several different theories aimed at explaining how it develops.

Xiao and colleagues (2018) simply described the "asymmetrical face-race experience," or an uneven distribution of the races of faces that the infants interact with by 9 months of age. They state that infants' perception is shaped by the individuals they regularly interact with. Similarly, Valentine's Face-Space theory (2016) suggests that this experience creates a "superior representation" of a certain race, species, or gender of a face (Valentine, Lewis, and Hills, 2016). The representation is thought to be comprised of an average of the faces of that race the infants have interacted with. This superior representation allows infants to discriminate between many faces of that face type. This face space is adaptable as infants and adults interact with more faces of another race (Kelly et al., 2007).

Markant and Scott (2018) suggest that the Other Race Effect stems from a shift in infant attention from bottom-up processing to a combination of bottom-up and top-down processing. They define bottom-up processing as stimulus-driven, while top-down processing is goal oriented. Because infants gain more control over their attention as the grow, they can gather the information from the stimulus and use it to work toward a goal, such as identifying an individual. They also describe attention weighting, which is defined as the distribution of attention based on its relevance toward current goals, and how attention weighting is directed toward individuals of the infants' own race as the infants develop.

As previously mentioned, many have come to a consensus as to the age at which the Other Race Effect develops. In terms of visual preference, most studies suggest that by the age of 3 months, infants prefer to look at faces of their own race (Liu et al., 2018, Sugden & Marquis, 2017, Xiao et al., 2018), at 6 months of age, infants do not have a preference of own- or other-race, and by 9 months of age, infants prefer to look at faces of other races (Sugden & Marquis, 2017). Sugden and Marquis (2017) explain that this difference in visual preference means that infants of all ages can at least categorize faces of their own and other races.

Many studies show that at 3 months, infants should be able to discriminate all faces, by 6 months, infants may only be able to discriminate most faces, and by 9 months, infants will show superior discrimination for faces of their own race (Kelly et al. 2007, 2009). After a meta analysis of studies on the Other Race Effect, Sugden and Marquis (2017) propose that there are three stages of perceptual narrowing and in the development of discrimination: the generalist stage, the slightly narrowed stage, and the narrowed stage. The generalist stage lasts from birth to 4.5 months of age, and during this time, infants may be able to distinguish all faces, regardless of visual preference. The slightly narrowed stage, in which infants can distinguish most faces, lasts from 5 to 7.5 months of age, and the narrowed stage, in which the infant can only distinguish faces of their own race, develops at 8 months of age.

Furthermore, studies have recorded a difference in facial scanning patterns of own- and other-race faces in infants. Hunnius, de Wit, Vrins, and von Hofsten (2011) describe facial scanning at 4 months to be meaningful if it is to the eyes and mouth. Liu and colleagues (2011) show that during the development from 4 to 9 months of age, infants scan internal features of the face (the eyes, nose, and mouth) progressively less in other-race faces. In fact, their study showed that older Chinese infants processed the inner facial features of their own race, however, the infants showed increased focus toward the outer features of Caucasian faces. Lesser looking to the inner regions of the face has been associated with inferior recognition in previous studies (Quinn, Lee, & Pascalis., 2018).

Kelly et al. (2007) tested for the presence of this phenomenon using 192 Caucasian infants, split between 3-, 6-, and 9-month olds. Three-month-old infants were chosen to participate because of previous studies explaining that younger infants have a visual preference for faces of their own race. Six- and nine-month-old infants were chosen to participate because of previous research showing that critical tuning of face processing happens within this period of development. To begin, each infant was habituated to a male or female face. This face was of African, Middle Eastern, Caucasian, or Asian descent. Eye tracking technology was then used during a visual paired comparison to track infant attention to the novel and familiar stimuli. They did not find significant differences in the 3- and 6-month-old age groups when viewing own- or other-race faces, however, they did find significant differences in the 9-month-old groups. In the older group, the infants in the Caucasian condition looked significantly longer at the novel faces during the visual paired comparison. This longer looking time suggests that 9-month-old

Caucasian infants are better at distinguishing between novel and familiar faces of their own race, and that this significant difference does not fully develop until the age of 9 months.

In a similar study, Kelly and colleagues (2009) aimed to determine when the Other Race Effect develops in infancy in other races. Kelly and colleagues decided to complete this study using Chinese infants to show that the Other Race Effect is a result of perceptual narrowing universally, rather than only in Caucasian infants. Three-, six-, and nine-month-old Chinese infants were habituated to a face of either Caucasian, Asian, or African ethnicity. Next, the infants were tested using a visual paired comparison of the familiar face versus a novel face of the same ethnicity. Results suggested that 3-month olds still had the ability to distinguish other-race faces, 6-month-olds had a slightly diminished ability to distinguish other-race faces, and by the age of 9 months, the infants were only able to distinguish Chinese faces.

It is believed that the enhanced ability to distinguish own-race faces comes from not only the experience that an infant has with their own race, but the more efficient scanning patterns the infants have adapted by 6 months of age. Liu and colleagues (2011) studied the relationship between infants' scanning patterns of own- and other-race faces to determine if there was a relationship between the development of scanning patterns and recognition ability. To do this, they familiarized Asian 6- and 9-month-olds to dynamic stimuli of Asian or Caucasian faces. Liu and colleagues (2011) state that dynamic stimuli were used as a more accurate measure of other- and own-race facial scanning, as the faces that infants interact with daily are dynamic. They then used a visual paired comparison with static stimuli to test recognition. Data was collected using an eye-tracker.

Results showed that infants scanned the eyes the most out of any inner facial feature, regardless of whether the face was of their own race or not. Additionally, they noted that the participants scanned the noses of their own race more than noses of another race, as well as scanning mouths of the other race more than mouths of their own race. Liu and colleagues (2011) explain that the discrepancy in nose scanning may be due to the nose being the identifying feature of the Asian face. This is consistent with findings from Blais, Jack, Scheepers, Fiset, and Caldara (2008), indicating that infants from Eastern cultures tend to not fixate on eyes and instead centrally fixate as a means of identification. The discrepancy in mouth looking is consistent with research from Wheeler and colleagues (2011), stating that infants do not scan the mouth in own-race faces for as long as they scan the mouth in other-race faces. They attribute the mouth looking in other races to the mouth being a distraction, which then causes the infant to not process other inner features of the other-race face. Most notably, Liu and colleagues (2018) found that 6-month-old infants scanned the dynamic stimuli from the familiarization phase exactly as they scanned the static stimuli from the test phases, but only in faces of their own race. This suggests that infants solidify scanning patterns for their own race before the age of 6 months.

Further research has been done to discover if it is possible to reverse the Other Race Effect, including later exposure to other race faces, also called experiential learning (Xiao et al., 2018). Experiential learning has been shown to reverse the Other Race Effect in adults (Xiao et al., 2018). Experiential learning also has been shown to reverse the Other Race Effect in infants, leading researchers to believe that this experiential learning may have a preventative effect on the Other Race Effect. A later study showed that daily experiences with Asian female faces led to a significant increase in recognition of novel Asian male and female faces in infant participants (Anzures, Quinn, Pascalis, Slater, & Lee, 2010). This study was carried out in 8- and 10-month-old infants, immediately after the Other Race Effect has completely developed. Labeling and naming other-race faces has also been shown to have a positive effect on infants abilities to distinguish novel other-race faces (Markant & Scott, 2018).

Additionally, research has been carried out to determine if affect, or emotional expression, has an effect on one's ability to distinguish other-race faces. This has been shown in adults, in which it is determined that adults show an "out-group bias." This bias is diminished when members of another racial group display an angry affect (Ackerman et al., 2006). Adults in this study showed lower recognition for other-race faces when showing a neutral expression that was not found for other-race faces showing an angry expression. Ackerman and colleagues (2006) attribute this effect to anger eliciting more attention in any race, as it is an interpersonal emotion, and therefore directly more threatening than sadness or fear. Likewise, others theorize that threatening stimuli may be most relevant because it directly relates to their innate want to survive (Peltola, Leppanen, Palokangas, & Hietanen, 2008).

There is evidence that infants also respond more rapidly to threat-related stimuli. Lobue and Deloache (2010) tested infants ages 8-14 months to determine the effects of threatening stimuli, such as snakes, versus non-threatening stimuli, such as flowers, on infant looking behaviors. They chose to use participants of this age based on their own previous research findings that infants of these ages respond more rapidly to snakes than to other non-threatening animals (2008). In the first trial, infants were shown 6 pairs of photos of flowers, snakes, and frogs, and then shown the same 6 pairs reversed to accurately measure looking for each stimulus.

The second trial used the same method using angry, happy, or fearful human faces. The results of the two experiments suggested that infants will orient more quickly to a threat-related stimulus than a non-threatening stimulus. There was not any difference in which stimulus the infants attended to first, only how quickly they attended to the angry versus happy stimuli. Lobue and Deloache suggest that this ability to quickly detect a threat may be due to a trait that has evolved over time in humans.

There has been an effect found in looking times based on affect within own race faces. Hunnius and colleagues (2011) studied 4-month-olds, 7-month-olds, and adults while they observed ten images of European-American female faces. The ages of the participants were chosen based on previous research showing that between 4 and 7 months of age, infants show differences in responsivity to differing emotional expressions. Each face showed one of five expressions: happy, neutral, angry, fearful, or sad. Each face was shown for ten seconds. Infants looked less at the inner facial features of faces displaying an angry or fearful affect. Instead, they concentrated on the entire face, indicating that the infants were more alert when threatening facial features were displayed. This may be because of the perceived threat associated with the emotion, or the lack of exposure the infants have had to the facial expressions.

The current study aims to determine if there is an interaction between affect and the Other Race Effect in infants. Previous findings indicate that before the age of 9 months, infants lose the ability to discriminate between other-race faces (Kelly et al., 2007, Liu et al., 2011). However, previous findings also indicate that positive (non-threatening) affect and negative (threatening) affect have varying effects on infant attention. Specifically, threatening emotional expressions, such as anger, elicit greater attention to facial features (Hunnius et al., 2011, LoBue et al. 2010). Therefore, we predicted that stimuli displaying angry affect may be associated with a reduction in the Other Race Effect in infancy, as compared to stimuli displaying a neutral affect (similar to the Ackerman and colleagues, 2006, findings with adults).

With the reasoning that the Other Race Effect fully develops before the age of 9 months, we selected 10-month-olds to participate in this study. This study utilized eye-tracking technology to collect data on novelty preference and scanning patterns throughout the experiment. The participants in this study were familiarized with a face of the African or Caucasian race displaying an angry or neutral affect. Similar to the Hunnius and colleagues' (2011) research, this study used only female faces, as infants are generally more efficient at processing female faces likely due to experience (Hunnius et al., 2011). The infants subsequently participated in a visual paired comparison task with faces of the same race and affect. This visual paired comparison was intended to determine if the participants could distinguish between the familiarized face and the novel face. Discrimination was determined by percentage of looking time to each stimulus as well as scanning patterns.

Methods

Participants

The current study included 15 10-month-old infants with a mean age of 315.4 days (SD= 9.58, range= 296-329). All participants were white, and the final number of participants consisted of 8 males and 7 females. Participants in this study were born full-term with no complications and had no known auditory or visual difficulties. Participants other than those in the final dataset were tested, however, some were not included due to inability to complete an adequate number of trials or fussiness (N= 13). Participants were recruited from the participant database maintained by the Child Development Research Group at the University of Tennessee through recruitment events. Participants were recruited without regard to gender, race, or ethnicity.

Participants were randomly assigned to participate in own- or other-race conditions, and within those, angry or neutral conditions first. Of the 15 participants, 8 viewed the other-race condition and 7 viewed the own-race condition. Trials were counterbalanced for affect.

Stimuli

The current study used 16 static stimuli of women's faces. The stimuli consisted of 8 women. Each woman's face was used twice, once with an angry expression and once with a neutral expression. The stimuli were of white and black faces only. Stimuli were used from the Chicago Face Database. The images of the faces were cropped into an oval shape immediately surrounding the faces, not showing any hair or ears. This was achieved using a custom Matlab program. Face stimuli used during the familiarization trial measured 26.0 x 17.5 centimeters and face stimuli used during the test trials measured 22.5 x 15 centimeters. Attractor stimuli during the trials measured 7.0 x 9.5 centimeters, while attractor stimuli between trials measured 3.0 x 3.0 centimeters. A white background was used for face and attractor stimuli. Eye-tracker calibration was completed using a 3-point calibration procedure. A target appeared at the bottom-left, bottom-right, and top-center of the monitor, accompanied by a quick sound at each point.

Apparatus

Testing took place in a room with lighting dimmed and black curtains surrounding the testing area to reduce distractions. Stimuli were displayed on a 17” Dell UltraSharp 1704FPV color LCD monitor. The corresponding speakers were out of view of the participant, behind the curtain, and presented the sound of the calibration and attention-getters at a volume of 55 dB. The desk-mounted infrared corneal reflection eye tracker (SR Research Ltd., Mississauga, Ontario, Canada, Eye-Link 1000 Plus) was positioned beneath the monitor, and recorded eye movements and visual fixations at a 500 Hz sampling rate. Experiment Builder software was used to present experimental stimuli and attention-getters (SR Research Ltd., Mississauga, Ontario, Canada).

Procedure

To begin, the experimenter reviewed experimental procedures with the participant’s guardian in order to receive informed consent. The caregiver was then given a certificate of participation, which they would keep whether the participant completed the study or not. The caregiver was then instructed to sit holding the participant facing the monitor. The seat for the caregiver was placed approximately 60 centimeters away from the monitor. The caregiver was advised to sit silently and not encourage any action from the participant.

A target sticker was placed on the participant’s forehead to aid with pupil localization in calibration. To complete calibration, the infant had to attend to each of the three calibration points. Validation was then completed to determine the accuracy of the calibration procedure. Once calibration and validation was complete, an attention-getter, such as a colorful bullseye, was presented at midline in the center of the monitor. In the familiarization phase of the trial, the participant accumulated 20 seconds of looking time to the designated familiar stimulus which one of the faces images with the actress displaying either angry or neutral affect. Accumulated looking to the face during familiarization was calculated online as the accumulated fixation length (based on summed fixations recorded by the eye tracker) on an area of interest (AOI) on the monitor that included the entire face region. The testing phase included a visual paired comparison (VPC) with the familiarized stimulus paired simultaneously with a novel stimulus, the novel stimulus was an image of a different actress displaying the same affect as the actress shown in the familiar stimulus. The paired stimuli were presented to the left and right of midline. After 5 seconds of combined looking time to the familiar and novel stimuli, the left and right positions of the familiar and novel stimulus were reversed, and another VPC lasting for 5 seconds of accumulated looking time to the paired stimuli was required to move to the next trial. Another attention-getter was first presented, followed by the beginning of the second trial, familiarizing the infant to whichever emotional expression they were not exposed to in the first trial. Order of affect used for first and second trials was counterbalanced across participants.

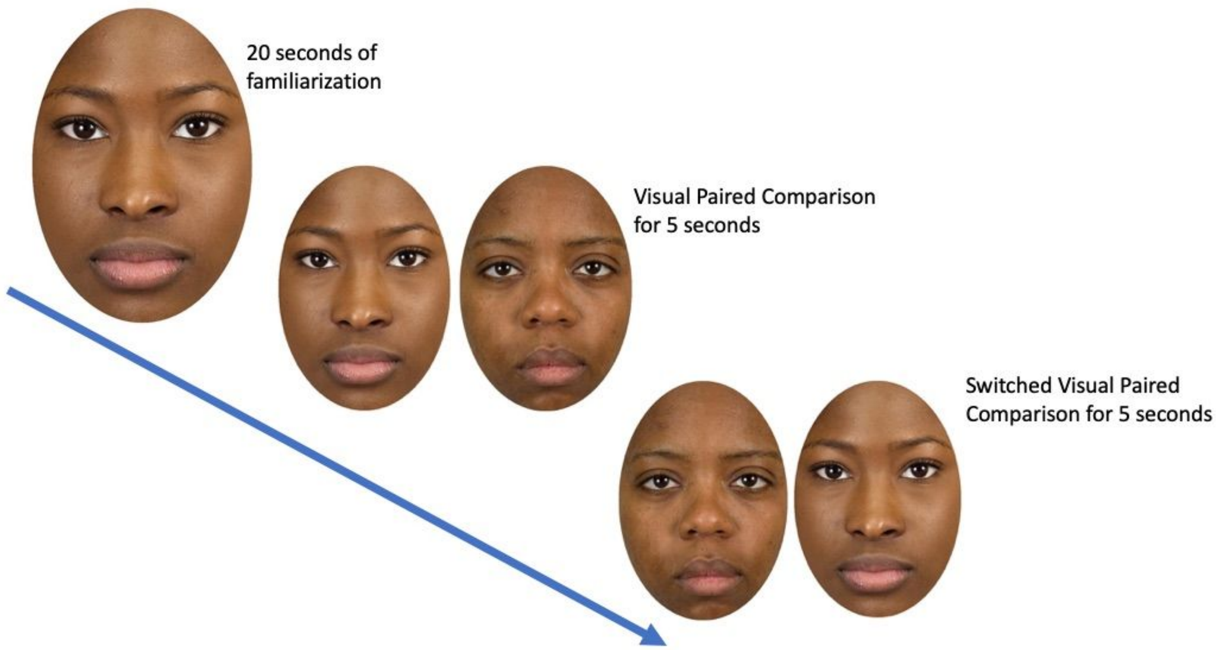

Figure 1. Example of one test trial. Each baby viewed only own- or other-race faces. Emotional expression was counterbalanced among participants.

Measurement

Proportion of looking was calculated to measure selective attention to regions of the face. Regions included in calculation were the outer face, mouth, nose, and eyes. These regions were defined by AOIs, marked by an oval space encompassing the entire face, an oval-shaped space around the mouth and jaw, a square space surrounding the nose, and a rectangle space encompassing both eyes. The duration of looking to each space was translated into a proportion, all adding to 1.00.

Results

Statistical Analysis Approach

Repeated measures ANOVAs examining the effects of the between-subjects factor of Face (2: Own-Race, Other-Race) and the within-subjects factor of Affect (2: Angry, Neutral) on infant scanning behavior were run separately on the eyes, nose, and mouth areas of interest (AOIs). Post-hoc analyses were completed using independent t-tests and paired sample t-tests. Effect scores were measured using η_p^2, and the alpha level was set at .05 for each test.

Figure 2. Visual heat maps of infants' scanning patterns in own-race neutral and angry conditions.

Figure 3. Visual heat maps of infants' scanning patterns in other-race neutral and angry conditions.

Selective Attention to the Eyes

The ANOVA run on selective attention to the eyes revealed a significant main effect of Race, $F(1,13) = 10.454$, $p < 0.01$, $\eta_p 2 = 0.45$. Post-hoc analysis revealed that infants looked significantly more at own-race eyes ($M = 0.69$, $SE = 0.03$) in comparison to other-race eyes ($M = 0.46$, $SE = 0.06$). There was also a significant interaction of Affect and Race on infant selective attention to eyes, $F(1,13) = 5.92$, $p = 0.03$, $\eta_p 2 = 0.31$. Infants displayed differential looking to own-race eyes based on affect ($p = 0.04$) with greater looking to angry own-race eyes ($M = 0.79$, $SE = 0.04$) compared to neutral own-race eyes ($M = 0.50$, $SE = 0.05$). Interestingly, no differences in looking to the eyes were found based on affect for other-race faces ($p = 0.36$)

Selective Attention to the Nose

There were no significant effects found on infant selective attention to the nose (all ps > .20).

Selective Attention to the Mouth

There was a significant main effect of Race on infant selective attention to mouth, F(1,13) = 7.034, $p < 0.02$, $\eta_p 2 = 0.35$. Post-hoc analysis revealed that infants looked significantly more at other-race mouths (*M*= 0.23, *SE*= 0.07) in comparison to own-race mouths (*M* = 0.03, *SE* = 0.01). No other main effects or interaction effects were found in the analysis of the mouth AOI (all *p*s > .40).

Novelty Preference

In addition to running the full factorial ANOVAs on visual fixation to the separate AOIs described above, one-sample *T*-tests were run separately by condition comparing the novelty scores infants demonstrated on the visual paired-comparison trials to a chance value of .50. Across all Race and Affect conditions, none of the novelty scores differed significantly from chance levels (all *p*s > .35).

Discussion

Scanning patterns of the stimuli in this study revealed that infants look less at the eyes of other-race faces and more at eyes of own-race faces, which aligns with the previously studied scanning patterns related to the other-race effect (Liu et al., 2018). Previous studies also suggest that infants may pay more attention to the mouth of other-race faces (Wheeler et al., 2011). Our data suggests that infants look more to the mouth region of other-race faces than own-race faces.

Infants scanned the eyes of their own race more when the stimulus showed an angry emotional expression than when they showed a neutral expression. This may be because infants are accustomed to scanning faces of their own race and using the eyes as an important emotional cue. However, infants did not display differential scanning of the mouths of own-race faces when there was an angry or neutral emotional expression. This may be due to the lack of social cues that may come from that region of the face. Interestingly, infants did not scan other-race faces differently based on an angry versus a neutral emotional expression.

Furthermore, we predicted that infants would show a novelty preference for own-race faces displaying either an angry or neutral affect, as well as show a novelty preference for other-race faces displaying an angry affect. This novelty preference would suggest that 10-month-old infants could discriminate between these faces. However, infants in the present study did not show a preference to any stimulus in any condition. This is contradictory to Ackerman and colleagues' (2006) findings, which show that in adults, recognition of other-race faces is higher when the face is showing an angry emotional expression versus a neutral expression. As previously stated, Ackerman and colleagues (2006) attribute this finding to anger being a more threatening emotion over other negative emotions such as sadness or fear. However, Ackerman and colleagues used adult subjects, who have had more experience with angry emotional expression throughout their lives and understand that this expression may indicate that there is a threat. Infants typically do not experience anger in their daily lives and may not recognize that there is a threat associated with this emotion. LoBue and colleagues' (2010) findings suggest that infants may orient more quickly to threat-related stimuli, however, they attribute this to an evolved survival trait rather than experience.

Limitations and Conclusions

One way this study may be improved is by increasing the sample size in each condition. Similar studies recruited sample sizes upwards of 100 participants, which may have produced more nuanced results. In the future, this study may be expanded to have a larger sample size or may be expanded to investigate how fear or sadness, less threatening emotions, affect infant looking and recognition.

The Other Race Effect is an important result of infant development within the first year of life. By understanding the effects of this perceptual narrowing, we may better understand the way that infants perceive the world around them. We can conclude, in alignment with previous literature (Liu et al., 2018, Wheeler et. al, 2011), that infants generally scan the faces of their own race significantly differently than faces of other races. Foremost, we know that infants primarily scan the eyes of faces of their own race, which differs from the comparatively holistic scanning of other-race faces. As the eyes serve as an important social and emotional cue, we can infer that infants may have an enhanced emotional processing ability for faces of their own race as opposed to faces of other races. This may be an effect of the expertise-like scanning that Liu and colleagues (2011) describe when studying the development of scanning patterns in own-race faces. The "asymmetric" experience with own- and other-race faces, as Xiao and colleagues (2018) described, can give infants superior experiences with varying emotions in faces of their own race versus faces of another race. Their past experiences contribute to their development of an efficient scanning pattern to better process different emotions they may see in their everyday life. Additionally, as Markant and Scott (2018) describe, infants begin to use top-down processing as the Other Race Effect develops, which is primarily goal-oriented. As infants develop an understanding of emotional expression within their own race and how different expressions may pertain to them, they may first process a face with the goal to understand its emotion. Overall, we believe that these results support that before 10 months of age, infants have an enhanced sensitivity to emotional expressions of faces of their own-race.

Works Cited

Ackerman, J., Shapiro, J., Becker, D., Kenrick, D., & Neuberg, S. (2006). They all look the same to me unless they're angry. *Psychological Sciences,17*(10), 836-840. doi:10.1037/e511092014-060

Anzures, G., Quinn, P., Pascalis, O., Slater, A., & Lee, K. (2010). Categorization, categorical perception, and asymmetry in infants' representation of face race. *Developmental Science*,*13*(4), 553-564.

Anzures, G., Wheeler, A., Quinn, P., Pascalis, O., Slater, A., Heron-Delaney, M., Lee, K. (2012). Brief daily exposures to Asian females reverses perceptual narrowing for Asian faces in Caucasian infants. *Journal of Experimental Child Psychology,112*(4), 484-495. doi:10.1016/j.jecp.2012.04.005

Blais, C., Jack, R., Scheepers, C., Fiset, D., & Caldara, R. (2008). Culture shapes how we look at faces. *PLoS ONE,3*(8). doi:10.1371/journal.pone.0003022

Hunnius, S., Wit, T. C., Vrins, S., & Hofsten, C. V. (2011). Facing threat: Infants and adults visual scanning of faces with neutral, happy, sad, angry, and fearful emotional expressions. *Cognition & Emotion,25*(2), 193-205. doi:10.1080/15298861003771189

Kelly, D., Liu, S., Lee, K., Quinn, P., Pascalis, O., Slater, A., & Ge, L. (2009). Development of the other-race effect during infancy: Evidence toward universality? *Journal of Experimental Child Psychology,104*(1), 105-114. doi:10.1016/j.jecp.2009.01.006

Kelly, D., Quinn, P., Slater, A., Lee, K., Ge, L., & Pascalis, O. (2007). The Other-Race Effect develops during infancy. *Psychological Science,18*(12), 1084-1089. doi:10.1111/j.1467-9280.2007.02029.x

Lewkowicz, D., & Ghazanfar, A. (2009). The emergence of multisensory systems through perceptual narrowing. *Trends in Cognitive Sciences,13*(11), 470-478. doi:10.1016/j.tics.2009.08.004

Liu, S., Quinn, P., Xiao, N., Wu, Z., Liu, G., Lee, K. (2018). Relations between scanning and recognition of own‐ and other‐race faces in 6‐ and 9‐month‐old infants. *PsyCh Journal*,*7*(2), 92–102. doi:10.1002/pchj.211

Liu, S., Quinn, P., Wheeler, A., Xiao, N., Ge, L., & Lee, K. (2011). Similarity and difference in the processing of same- and other-race faces as revealed by eye tracking in 4- to 9-month-olds. *Journal of Experimental Child Psychology,108*(1), 180-189. doi:10.1016/j.jecp.2010.06.008

Lobue, V., & Deloache, J. (2010). Superior detection of threat-relevant stimuli in infancy. *Developmental Science,13*(1), 221-228. doi:10.1111/j.1467-7687.2009.00872.x

Markant, J., & Scott, L. (2018). Attention and perceptual learning interact in the development of the Other-Race Effect. *Current Directions in Psychological Science,27*(3), 163-169. doi:10.1177/0963721418769884

Peltola, M., Leppänen, J., Palokangas, T., & Hietanen, J. (2008). Fearful faces modulate looking duration and attention disengagement in 7-month-old infants. *Developmental Science,11*(1), 60-68. doi:10.1111/j.1467-7687.2007.00659.x

Quinn, P., Lee, K., & Pascalis, O. (2018). Perception of Face Race by Infants: Five developmental changes. *Child Development Perspectives,12*(3), 204-209. doi:10.1111/cdep.12286

Sugden, N., Marquis, A. (2017). Meta-analytic review of the development of face discrimination in infancy: face race, face gender, infant age, and methodology moderate face discrimination. *Psychological Bulletin*, *143*(11), 1201–1244. doi:10.1037/bul0000116.

Valentine, T., Lewis, M., & Hills, P. (2016). Face-space: A unifying concept in face recognition research. *Quarterly Journal of Experimental Psychology,69*(10), 1996-2019. doi:10.1080/17470218.2014.990392

Werker, J., & Tees, R. (1984). Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. *Infant Behavior & Development, 7*(1), 49-63. http://dx.doi.org/10.1016/S0163-6383(84)80022-3

Wheeler, A., Anzures, G., Quinn, P., Pascalis, O., Omrin, D., & Lee, K. (2011). Caucasian infants scan own- and other-race faces differently. *PLoS ONE,6*(4). doi:10.1371/journal.pone.0018621

Xiao, N., Mukaida, M., Quinn, P., Pascalis, O., Lee, K., & Itakura, S. (2018). Narrowing in face and speech perception in infancy: Developmental change in the relations between domains. *Journal of Experimental Child Psychology,176*, 113-127. doi:10.1016/j.jecp.2018.06.007

Xiao, Naiqi & Quinn, P.C. & Lee, Kang & Pascalis, Olivier. (2017). Processing of face race in infants: Development of perceptual and social biases. 1-15.